

Soil Moisture Memory in AGCM Simulations: Analysis Global Land-Atmosphere Coupling Experiment Simulations

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Abstract

Soil moisture memory is a key aspect of land-atmosphere interaction and has major implications for seasonal forecasting. Due to a severe lack of soil moisture observations on most continents, existing analyses of global-scale soil moisture memory have relied previously on Atmospheric General Circulation Models (AGCMs) experiments, with derived conclusions that are probably model-dependent. The present study is the first survey examining and contrasting global-scale (near) monthly soil moisture memory characteristics across a broad range of AGCMs. The investigated simulations, performed with 8 different AGCMs, were generated as part of the Global Land-Atmosphere Coupling Experiment. Overall, the AGCMs present relatively similar global patterns of soil moisture memory. Outliers are generally characterized by anomalous water-holding capacity or biases in radiation forcing. Water-holding capacity is highly variable among the analyzed AGCMs and is the main factor responsible for inter-model differences in soil moisture memory. Therefore, further studies on this topic should focus on the accurate characterization of this parameter for present AGCMs. Despite the range in the AGCMs' behavior, the average soil moisture memory characteristics of the models appear realistic when compared to available in-situ soil moisture observations. An analysis of the processes controlling soil moisture memory in the AGCMs demonstrate that it is mostly controlled by two effects: evaporation's sensitivity to soil moisture, which increases with decreasing soil moisture content, and runoff's sensitivity to soil moisture, which increases with increasing soil moisture content. Soil moisture memory is highest in regions of medium soil moisture content, where both effects are small.

Popular Summary

Soil moisture memory (e.g., the degree to which a “wetter than normal” soil moisture remains wet into the future) is a critical element of the land-atmosphere system and has major implications for seasonal forecasting – if, through this memory, we can predict soil moisture into the future, and if precipitation responds consistently to soil moisture anomalies, then the ability to forecast precipitation is increased. This paper presents the first comprehensive survey of soil moisture memory in present-day climate models. Although the models do show strong differences in simulated memory, due mostly to differences in assigned water-holding capacity, the models present similar patterns in the memory, with higher values in regions of medium soil moisture content. The analysis shows that in these intermediate regions, the ability of evaporation and runoff processes

to diminish the memory is reduced. Overall, the average soil moisture memory characteristics of the models appear realistic when compared to the (very limited) available observational data.